CHAPTER 11

ALIGNMENT

For any weapon system to be effective, the destructive device must be delivered to the target accurately. Many air targets are now capable of speeds faster than sound; therefore, they must be detected and engaged at greater distances. Technological improvements in modern weapons systems require that equal improvements be made in their associated detection and fire control systems. Proper battery alignment is a must if ordnance is to be delivered on target.

In this chapter we will describe the basic fundamentals of alignment principles and battery alignment. We will also discuss firing cutout mechanisms, radar alignment, and the final alignment and test.

ALIGNMENT PRINCIPLES

LEARNING OBJECTIVES: Describe alignment principles and procedures on naval gun systems.

The elements of a modern combat system must work together with a great degree of accuracy to deliver ordnance on target. All are electrical y and/or mechanically linked to pass data from one unit to the next. Each equipment with alignable properties must be aligned to a common reference to ensure a correct exchange of data between the various systems. Data transmission and response synchros must be properly zeroed. All gun bores, missile launchers, fire control directors, radar antennas, gyrocompasses, and other similar pointing lines must be parallel (when no parallax or ballistic corrections have been made). Combat system alignment is the process of establishing parallelism, within acceptable tolerances, between the elements of the combat system.

In this section we will describe the sequence used in establishing combat system alignment. Following that, we will discuss the more familiar sequence of alignment verification.

SEQUENCE OF ALIGNMENT

Combat system alignment begins with the design of the ship. Alignment is established as the ship is constructed. Once constructed, alignment is continually perfected up to the point where the ship is placed in commission and its permanent operational crew is on board. As a ship goes through its normal life cycle, it is the job of the crew to verify this alignment continually, making corrections as necessary.

Certain steps in a combat system alignment process must be accomplished according to a specified sequence. The sequential steps are as follows:

1. Establishment of reference planes
2. Establishment of reference marks
3. Establishment of parallelism
4. Performance of fire control radar radio frequency (RF)—optical alignment
5. Performance of train and elevation alignment
6. Establishment of benchmark and tram reference readings
7. Performance of dynamic train alignment

Establishment of Reference Planes

The first major alignment step is the establishment of reference planes. A position can only be described by relating it to a known reference point. Reference planes allow combat system elements to be described as to how they are situated in relationship to each other. Reference planes are established during the initial construction of the ship and are used as required during alignment of the combat system. Reference planes consist of the center-line reference plane (CRP), the ship base plane (SBP), the master reference plane (MRP), and the weapons control reference plane (WCRP).

CENTER-LINE REFERENCE PLANE.— The center-line reference plane (CRP) is the first plane established. It is the plane containing the ship's center line and is perpendicular to the SBP. The CRP is the reference used to establish the train zero alignment of all of the combat system equipment.

SHIPBASE PLANE.— The shipbase plane (SBP), the basic plane of origin, is perpendicular to the CRP and includes the base line of the ship, but is not necessarily parallel to the keel.

MASTER REFERENCE PLANE.— The master reference plane (MRP) is a plane within the ship parallel to the SBP. On most ships, the MRP is represented by a master level plate that has been accurately leveled to the SBP and aligned in bearing to the CRP. The MRP is used as the machining reference to establish the foundations of the combat system equipment. After initial construction alignment, the MRP is only used as a reference plane following major damage or modernization.

WEAPON CONTROL REFERENCE PLANE.— The weapon control reference plane (WCRP) is established during initial construction and is usually represented by the roller path plane (RPP) or the equipment that has been designated the alignment reference. This is the plane, which most people are familiar with, that is involved with alignment verification. On the FFG-7 class ship, for example, the WCRP is the roller path of the Mk 75 gun mount.

Establishment of Reference Marks

The second major alignment step is the establishment of reference marks. Reference marks include center-line reference marks, offset center-line reference marks, and equipment bench marks.

CENTER-LINE REFERENCE MARKS.— Center-line reference marks are established during initial construction to represent the ship's center line. Several small plates (at least two forward and two aft) will be installed at intervals along the center line to indicate its location.

OFFSET CENTER-LINE REFERENCE MARKS.— Offset center-line reference marks are also established during initial construction to facilitate the combat system alignment. The offset center line is established parallel or perpendicular to the ship's center line. These marks are installed to prevent repeating the center-line survey during subsequent alignments. They must be maintained within 1 minute of arc of the CRP.

BENCH MARKS.— Bench marks are the most familiar of all the reference marks to the average equipment operator/maintenance person. A bench mark is installed for each equipment that has an alignment telescope. Bench marks are installed at any convenient location that is visible through the equipment telescope. Equipment bench marks are used throughout the life of the ship to verify alignment.

Establishment of Parallelism

The third major alignment step is the establishment of parallelism between the roller path planes (RPPs) of all the equipment in the combat system. This step is also accomplished during initial construction. It is accomplished again as new systems are added or old equipment is replaced. The steps necessary to achieve the required degree of parallelism are foundation machining, inclination verification, and interequipment leveling.

FOUNDATION MACHINING.— Before the combat system equipment is installed aboard ship, the equipment foundations are machined so that the planes of the foundations are parallel, within tolerance, to the reference plane and then smoothed to the required flatness.

When the equipment is mounted aboard ship, the RPPs will not be precisely parallel. It is not possible under normal conditions to attain perfect accuracy in machining or in the construction of equipment. There will always be some error. However, once machined within tolerance, there are devices incorporated into most equipment that can be adjusted to compensate for roller path alignment error. These devices are discussed later.

INCLINATION VERIFICATION.— Inclination verification consists of the measurement of the tilt between equipment RPPs of the equipment in the combat system and the reference plane. Figure 11-1 shows a plane tilted with respect to the reference plane. Note that the inclination varies with the bearing. In the direction of line OA, the inclination is zero. Inclination increases gradually in the direction of line OB until it reaches maximum positive angle at 90° from line OA. Point B is the <u>bearing of the high point (Bhp).</u> Point D is a negative angle, proportionate to the positive angle of point B. All the references to roller path alignment are expressed in terms of the bearing and inclination of the high point. The tilt of the RPP is determined by using clinometers or similar devices.

INTEREQUIPMENT LEVELING.— YOU can accomplish equipment leveling through the use of leveling rings, shims, adjusting screws, equipment adjustments, or offset by software.

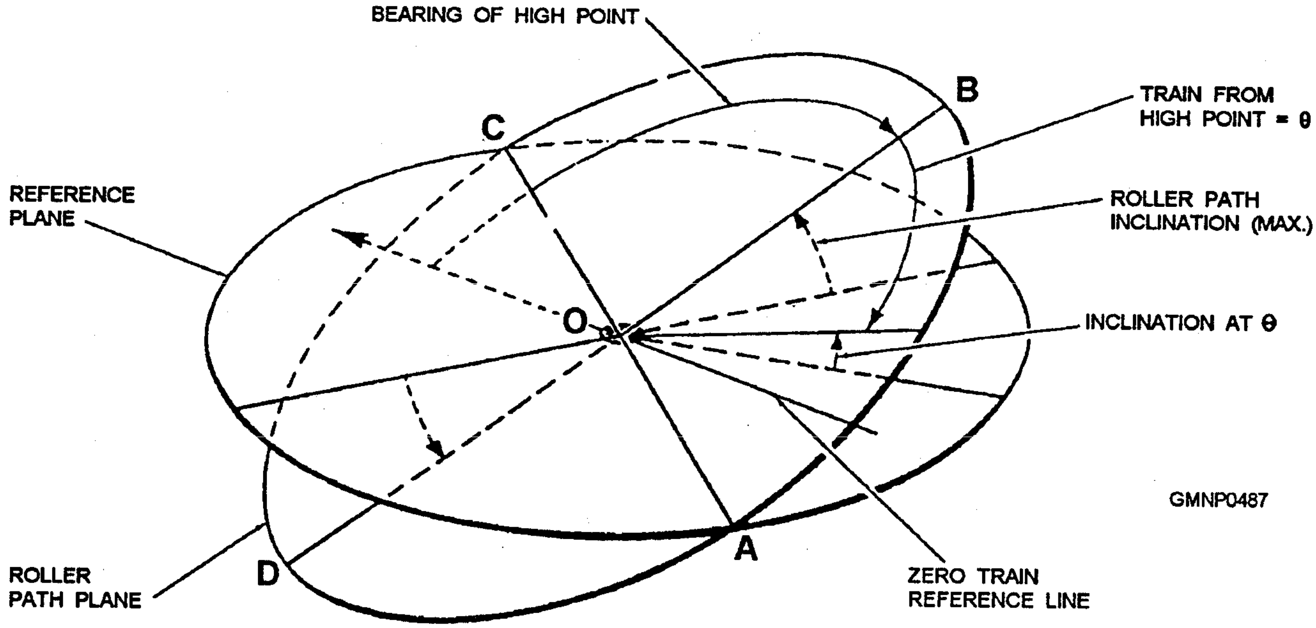

Figure 11-1.—Variation of roller path inclination with bearing.

A common device used to offset the effects of roller path misalignment is the roller path compensator. The roller path compensator is incorporated into the elevation receiver-regulator of most gun mounts. It is connected through gears and linkages to the train drive unit. The roller path compensator is set with the bearing and magnitude (in minutes) of the high point. As the gun moves in train, the compensator is moved and either adds or subtracts from the elevation order the number of minutes necessary to cancel out the roller path error at that bearing. For further information on roller path alignment, see NAVSEA OP-762, chapter 5.

Performance of Fire Control Radar RF-Optical Alignment

The fourth major alignment step is the verification of fire control RF-optical alignment (collimation). This is the alignment between the axis of the RF energy beam emitted by the fire control radar and an optical device attached to the radar antenna. During initial installation, the alignment is established and the optics are secured in place. During subsequent alignment checks, you can make adjustments to correct any errors detected. Radar collimation checks are normally conducted using a certified shore tower facility. Some radars, however, may be collimated while tracking a target. Figure 11-2 shows the essence of radar collimation.

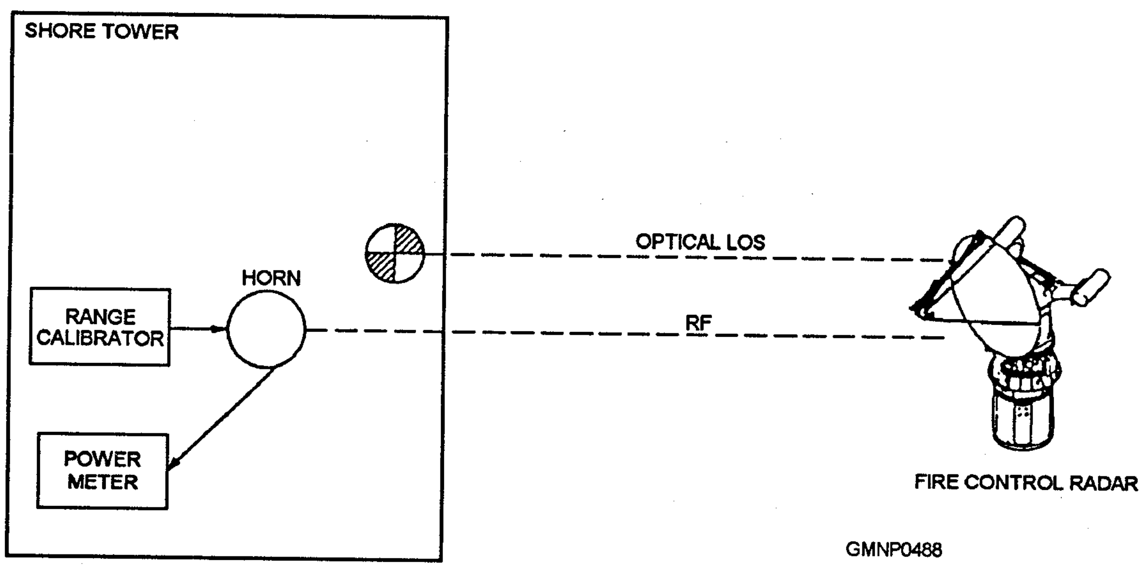

Figure 11-2.—Radar collimation.

Performance of Train and Elevation Alignment

The fifth major alignment step is the performance of train and elevation alignment. This alignment is performed by fleet support personnel to make sure the pointing lines are parallel. This procedure is the same one performed by fleet personnel to verify system alignment. Two procedures can be used for train and elevation alignment. The first is the establishment of train and elevation zero (theodolite method); the second is the train and elevation space alignment (star check method).

The theodolite method aligns train zero to the center-line reference plane and elevation zero to the roller path plane of the equipment. The more familiar star check method establishes parallelism between combat system elements by having them all sight on a celestial body, then aligning their dials to match those of the weapons control reference plane (WCRP). The star check method will be discussed further in the next section of this chapter.

Establishment of Bench Mark and Tram Readings

The sixth major alignment step is the establishment of bench marks and tram reference readings to furnish an easy means of verifying the alignment of equipment in the future. It is necessary to have reference readings because the equipment position data dials and data transmission synchros may become misaligned due to wear, vibration, or normal maintenance. These reference readings are normally established by a shipyard or NAVSEA representatives after all of the system elements are aligned. The application of these reference readings will be discussed further in the next section of this chapter.

Performance of Dynamic Train Alignment

The last major step is the train alignment between the reference and alignable combat system equipment not equipped with a telescope. This is accomplished by comparing equipment position with the position of the alignment reference while simultaneously tracking an isolated target. Fleet and fleet support personnel conduct this alignment.

These steps are used to establish the combat system alignment. Shipboard personnel are not usually directly involved in most of this process. What we have described thus far is what takes place while a ship is being constructed or in a major overhaul. established, it is the responsibility of shipboard personnel to verify and maintain the alignment of the system. This is the part of the combat system alignment that is more familiar to most fleet personnel.

ALIGNMENT VERIFICATION

Several procedures are fundamental to alignment verification. In this section we will describe a typical gun mount alignment verification procedure, including tram and bench mark readings and star checks. Since each system is configured differently, we will not attempt to explain in any detail how corrections are actually made.

Tram and Bench Mark Readings

Once established, tram and bench mark readings give the maintenance person a ready reference to check the alignment of the equipment. Apiece of equipment will be fitted either for tramming or with a fixed telescope for sighting a bench mark. Typically, gun mounts and missile launchers are *trammed,* while directors are *aligned* to bench marks. Some systems, however, may be fitted for both.

TRAM.— A gun mount is fitted with two sets of tram blocks-one set each for train and elevation. The blocks are welded, one to the rotating element and the other to a stationary element nearby. Elevation tram blocks are attached, one to the underside of the slide and the other to the trunnion support. Train tram blocks are attached, one to the bottom of the carriage and the other to the stand. Tram blocks are provided with machined plates with concave centers that fit the ends of the tram bar. The telescoping tram bar is the most common type in use and will be the only type discussed here.

The telescoping tram bar consists of two parts, one sliding inside the other. The parts have a small movement with respect to each other and are extended by an internal spring. Ascribe mark on the inner part is visible through an opening in the outer part. Engraved on the edges of the opening is a zero mark. When the inner scribe mark and the outer zero mark are aligned, the tram bar is at the correct length. The tram bar is placed in the tram blocks, and the gun mount is trained or elevated to compress or expand the bar until the marks are aligned. This serves to place a known distance between two fixed points, corresponding to a specific train or elevation angle. Once this angle is determined, it becomes the reference for future alignment verification.

Figure 11-3 shows a tram bar installed in a set of gun mount train tram blocks. Tram readings are taken as an average of several readings. The air drive motors are used to move the gun mount. Several readings **are** taken, moving the mount to compress the tram bar into alignment alike number of readings are taken, moving the mount to extend the bar into alignment. By moving the gun mount in both directions, you can detect any **lost** motion in the gear train. The readings are then averaged and compared to the reference readings that are inscribed on a plate normally attached to one of the trunnion supports.

NOTE

Elevation tram readings are almost always taken with the gun mount trained to 90° from the bearing of the high point. At any other train bearing you will get erroneous elevation readings due to the offsetting inputs of the roller path compensator. Refer to your ship's alignment manual for exact instructions for avoiding this situation.

BENCH MARK— The bench mark is used much the same as tram readings. The equipment to be aligned trains and elevates to align the telescope cross hairs with the bench mark. The bench mark, however, may be some distance from the equipment you are aligning. This increases the probability that the bearing to the bench mark will change in relation to your equipment due to hull distortion. No alignment adjustments should ever be performed based on a single tram or bench mark reading.

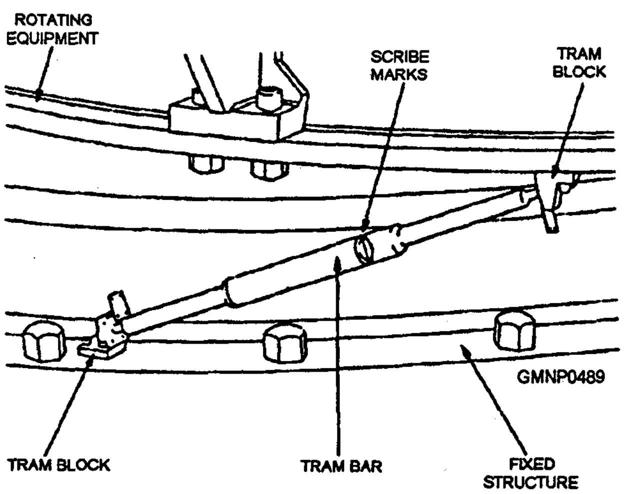

Figure 11-3.—Tram bar and tram blocks.

Star Checks

Star checks are used to verify parallelism between elements of the combat system and the WCRP. To illustrate this process, we will assume that the gun director is also the WCRP. We will now align the gun mount to the director. To begin with, you can fit the gun with a borescope and all the ballistic and parallax corrections are set at zero by the GFCS. The borescope is inserted into the breech of the gun and its cross hairs aligned with the axis of the bore.

In the evening, a celestial body (star) is selected, and the directories moved to track the star with its optics. Be careful not to choose a satellite. Satellites show up early and are usually very bright. This makes them tempting choices for star checks. However, once you have locked onto a satellite, you will find that it moves very quickly across the sky, making it difficult to track.

The gun is driven simultaneously with the air drive motors to track the same star through the borescope. Once the star can be seen through the optics of both the gun and the director, each is moved to pass the vertical or horizontal cross hair over the star. When the star is centered in the cross hair, the person at the telescope gives a "MARK." When both the director and the gun MARK at the same time, all the movement is stopped and the dials are read This is done several times from each direction from the bottom and the top in elevation and from the left and the right in train. Each crew then averages their train and elevation readings individually. The averages are compared and the gun is adjusted to the director if the error is out of tolerance.

Each time this is accomplished, the results of the verification, as well as any adjustments, are recorded in the Combat Systems Smooth Log. Refer to *Align Theory,* SW225-AO-MMA-010/OP762, and the appropriate volume of the SW225-XX-CSA-010 series of publications pertaining to your ship type for further information on combat systems alignment procedures.

BATTERY ALIGNMENT

LEARNING OBJECTIVES: Discuss the purpose and procedures for proper battery alignment.

The purpose of battery alignment is to adjust all the elements of a weapons system and fire control system so that the weapons can be accurately aimed and the ordnance delivered on target. In other words, you should target the gun barrel to the exact point that the gun radar or sight is centered on.

Several things may cause your systems to be out of alignment—normal wear and tear, gun-bore erosion, improper maintenance, alterations/modifications to the system or ship, and so on. Initially, alignment is accomplished in the shipyard by the builder, but the continued accuracy of the ordnance installation relies upon constant maintenance.

SHIPYARD ALIGNMENT

The alignment of a weapons system is primarily concerned with the directions that the equipment (launchers, guns, directors, etc.) are pointed. To establish directions, you must use a definite and complete set of geometric references. The necessary references are contained in the geometric structure, called a reference frame. The reference frame consists of a reference point, a reference direction, and a reference plane.

Directions are expressed by giving instructions from a specific point. Any desired point maybe selected as the starting point, and once this selection has been made, it becomes a part of any measurement. Since this measurement must refer to the starting point, it is called the reference point.

After a reference point has been selected, it is necessary to have a reference direction from which to measure angles. The angles are measured about the reference point, starting from the reference direction. In naval ordnance, a fore-and-aft line, pointing in the direction of the ship's bow, is the most frequently used reference direction.

Angles expressing direction cannot be described completely unless a means is available for specifying the particular planes in which the angles are to be measured. This condition is met when a reference plane is selected. The horizontal plane (also called a deck plane) is one of the most commonly used reference planes. When the ship is afloat and you are comparing the horizontal plane to several other planes, two spirit levels are necessary for each comparison—the inclination of one plane with respect to another.

The three references described in the preceding paragraphs must all be used when measurements are given to describe directions. In the complete reference frame, directions are specified by two angles measured about the reference point. One angle is in the reference direction, and the other angle is a plane perpendicular to the reference plane and is measured from the reference plane.

Before any alignment can be accomplished on a new ship, you must establish the reference frame. During the construction of a ship, one baseplate is installed within the ship's hull. This plate is referenced to a similar plate on a fixed ground installation. The plate is leveled as accurately as possible before the ship is launched, and an imaginary base plane is figured from the average readings taken from the baseplate. The foundation and the roller paths for the fire control directors, launchers, and gun mounts are machined so that they are (as nearly as possible) paralleI with the base plane. The fire control reference plane or weapons control reference plane (WCRP) is the horizontal plane to which all combat system elements are aligned. The WCRP is perpendicular to the ship's center line (SCP) and parallel to the ship base plane (SBP). In practice, it is defined by the roller path plane of one and sometimes two of the major elements of the ship's combat systems installations.

After battery alignment in train has been accomplisheed, you can begin alignment in elevation. The purpose of this alignment phase is to set all the elements so that when they are positioned in elevation with their lines of sight parallel to their own roller path plane, the elevation dials of all the elements will read zero and the elevation synchros will be at electrical zero.

So that guns, directors, and launchers can be realigned to the same position, you can provide bench marks and tram readings. Once established, tram and bench mark readings give the maintenance person a ready reference to check the alignment of the equipment. Apiece of equipment will be fitted either for tramming or with a fixed telescope for sighting a bench mark. Typically, gun mounts and missile launchers are *trammed*, while directors are *aligned* to bench marks. Some systems, however, may be fitted for both. Upon completion of initial alignment or subsequent realignment by shipyard or support activities, you must submit a shipyard alignment report to the commanding officer of the ship. Included in this report are the alignment data, tolerances, demonstration results, and any other pertinent data for all of the combat systems and subsystems aligned by shipyard personnel. This data is maintained in the Combat Systems Smooth Log.

SYSTEM ALIGNMENT

Shipyard personnel initially install equipment using precision methods in a newly constructed ship. They take into account stress caused by operational loading and adjust for accurate alignment when the ship is waterborne and contains 90 percent of the total load (builder yard only). When alignment procedures are undertaken thereafter, the ship should contain 80 percent of the total load of fuel, water, armament, and stores, distributed normally. The greater part of the work will consist of checks and small adjustments unless the equipment has been damaged or moved out of alignment.

System alignment requires orienting and adjusting several components to each other so that they function properly together as a whole. No alignment work should ever be undertaken without first making careful tests to make certain that adjustment is necessary. An incorrect or unnecessary adjustment can cause serious problems in the system.

SHIPBOARD ALIGNMENT

The alignment requirements for a weapons system include the internal alignment of each of the components and system alignment of the different components or equipment with each other. The internal alignment of an ordnance component is established by the manufacturer. A high degree of machining and fitting of structural parts assures good internal alignment. If any basic alignment is necessary because of faulty manufacture, overhaul at a shipyard usually is required. Each director should be internally aligned with the ship's references. All the parts of the weapons system are aligned to the reference while the ship is being outfitted or in dry dock, and the whole system is tested. When the ship is afloat, you must recheck the operation of the system. If there are serious distortions, the ship is returned to the shipyard for adjustments.

The launchers and gun mounts must be aligned to the directors in train and elevation.

Before any alignment work is undertaken afloat, you should perform a transmission check. Synchro and dial errors corrected at this point will keep you from compounding the errors or from introducing errors into the ensuing alignment procedures. Initially undetected errors would be revealed before the alignment was completed. At this point, you could be faced with the task of redoing one or more of the alignment phases.

You should not proceed with synchro alignment unless the preliminary checks show a misalignment. If the synchro is close to zero, you should make only the fine adjustment.

MOUNT ALIGNMENT

Precise mount alignment requires extreme accuracy in the performance of alignment checks and adjustments. These checks should be made with the ship moored to a pier or anchored in calm seas.

Train alignment checks provide an accurate method of determining the degree of parallelism between the zero train lines of all the components of the system. When the director is trained to any point and the mount dial pointers are matched with zero settings, the director and mount lines of sight are parallel in train.

Because the ship is afloat, it is impracticable to use multiple targets to obtain parallelism between the mount and director. However, if the lines of sight of both the director and the mount are aligned on a target at infinite range, they will, for all practical purposes, be parallel. The most accurate method of alignment is to use a celestial body.

When train alignment is performed simultaneously for several components, the train dial readings from all the stations should be transmitted to a central station (such as CIC) for systematic recording. The recorders at the individual components should cross-check all the readings to eliminate possible errors in recording the readings. Rotation of the earth and ship's motion may cause the line of sight to drift from the target, but this drift is not detrimental as long as the line of sight is on the target when the reading is taken.

The mount is aligned in elevation to the director. It is elevated in manual control to bring its bore (or launching rail) into a position parallel to its roller path plane (at a point of known inclination) within 3 minutes of arc. All the elevation indicators are adjusted to indicate zero elevation.

FIRING CUTOUT MECHANISMS

LEARNING OBJECTIVES: Discuss the importance of firing cutout mechanisms.

It is hard to overstate the importance of checking the firing cutout mechanisms after making the original alignment or after doing any work or repair on the mount that would disturb the firing cutouts. Every casualty caused by the ship's firing into their own superstructures testifies to the seriousness of any misalignment of the firing stop mechanisms. In every case, these casualties could have been prevented. These casualties have resulted from negligence on the part of ship's force personnel-the cams were cut improperly (in some cases misaligned) or the firing cutouts were inoperative through a lack of preventative or corrective maintenance.

As you may remember, firing cutout mechanisms are designed to interrupt electrical firing circuits and firing mechanism linkages whenever guns and launchers are trained or elevated to position where firing the mount would endanger personnel or cause damage to the ship. They should not be confused with the limit-stop assemblies that are used to limit the movement of some mounts to a safe firing zone. Firing cutout mechanisms do not interfere with the free movement of the gun or launcher.

The Naval Sea Systems Command has issued definite instructions for personnel responsible for plotting, cutting, installing, and checking firing cutout cams and mechanisms. These regulations are to be complied with in all cases. In addition, special instructions govern particular installations. The computations for the safety clearances of the mount relative to the ship's structures and equipment are complicated and extensive. A high degree of precision and skill is required to make these computations and to prepare and install the cutout cams in the mount. The computations are now done with computers at the Naval Surface Weapon Center (NSWC), who prepares the cutout data for the requesting ship. NSWC also prepares the cutout cams and assists in their installation and adjustment.

When anew cam is installed, it is essential that the two train reference points be reestablished. These are the train B-end stopped position and the nonpointing zone cam arrested position. The nonpointing zone switches must be set accordingly. NSWC personnel will assist in performing this task

The firing cutout cams are plotted, scribed, and cut during the final stages of the initial installation or overhaul period. This is accomplished after all the installation and alterations to the topside, superstructure, masts, and rigging are completed.

Procedures for scribing and matching the firing cutout cams are outlined in the applicable system OPs.

Performance of the cams should be checked before each firing, whenever new cams are installed, and as prescribed by the PMS schedule of your system.

The train and elevation limit stops restrict mount movement under certain conditions. When activated, the limit-stop system neutralizes the associated power drive, thus limiting the movement of the mount. The limit-stop cam controls the deceleration rate of the power drive of the mount. Train and elevation require different rates of deceleration, so their cams differ in contour. The actuating cams are identical. When the mount approaches a nonpointing zone, the actuating cams start the limit-stop system.

An adjustment screw is secured to the bottom of each limit-stop cam. As an aid in alignment, scribe lines are scored into the cams. The cam-stacks, which indicate position-plus-lead to the automatic-pointing-cutout and automatic-firing-cutout systems, have a vernier that permits simultaneous adjustment of all of the cams in the stack, and each cam can be adjusted to a vernier in its base.

Firing cutout cams, limit-stop cams and associated shafts, switches, and components are preset by the manufacturer and checked by the installing activity. These cams do not require routine adjustment. They should be checked periodically and reset only if they are not within plus or minus 1° of actual mount settings.

RADAR ALIGNMENT

LEARNING OBJECTIVES: Discuss the importance of radar alignment on a guided missile battery.

All the elements of a guided missile battery are aligned in the same manner as a conventional weapons battery. There is, however, one additional step you must accomplish before the physical alignment of the battery. You must first align the radar reference beam and the boresight telescope of the radar antenna. This can be accomplished by using a shore tower approximately 100 feet high and at least 1,300 feet from the ship. The tower must be equipped with an optical target and a tunable radar transmitter.

On some missile systems, the radar beam is used as the reference for this alignment. The radar beam is trained and elevated to the tunable radar transmitter and electrically aligned. The boresight telescope is then adjusted to the optical target and locked in place. In other missile systems the boresight telescope is the reference. The boresight telescope is trained and elevated to the optical target on the tower and then the radar beam is aligned to the tunable transmitter. This is the most critical alignment, because, in both cases, the boresight telescope, after alignment, becomes the only reference line of sight for the director. Benchmark data is provided to check this optical alignment periodically.

The above explanation is for dry dock alignment performed by shipyard personnel, perhaps assisted by the ship's force personnel. When the ship is afloat, the radar reference beam is again checked by the ship's force. While at the pier, the shore towers are used. At sea, all the guided missile ships will use bow and/or stern towers installed according to current NAVSEA instructions. Each tower will contain an optical boresight target, a capture antenna, and a track and guidance antenna.

FINAL ALIGNMENT AND TEST

LEARNING OBJECTIVES: Discuss the importance of testing after a battery alignment and recording the results in the Combat Systems Smooth Log.

The success of a weapons system depends to a great extent upon the mechanical and electrical alignment of the system. Minor errors in synchro or dial adjustments can result in missing the target by a great distance.

If any error corrections were made to train or elevation receiver-regulator dials, you must establish new alignment readings. Obtain the detailed instructions for your system and follow them with care.

Upon completion of the train and elevation checks, the elements of the system are rechecked against their respective bench marks and new dial readings are recorded in the ship's battery alignment and fire control smooth logs.

Although both of the above tests can and should be conducted by the ship's force, it would be wise to ask for technical assistance from a repair facility if you are unsure of the procedures.

Modern ordnance installations are operated almost exclusively in automatic control, except under certain special conditions or in emergencies. Therefore, it is especially important for an installation to be aligned accurately for automatic operations. If the alignment methods described in this chapter are used so that the dials of each element are aligned accurately with the dials of the reference element, you should end up with a good alignment. It is advisable to check the results under conditions which approximate those under which the equipment will be used. The checks should be performed with the system in automatic control and with the parallax equipment functioning.

If possible, select several targets with different bearings and at ranges that will be as close as possible to the mean battle range for the equipment. For antiaircraft installations, try to use air targets which are at an elevation angle near 45°. The target should produce a slow bearing so that accurate tracking is not difficult.

Train and elevate the director to track a target as accurately as possible, especially in train. When on target, the director-trainer will call "MARK" by telephone to the operators at their stations. The operator at each station observes the target through the boresight telescope or the boresight and makes a note of any train error present when the director is on the target. This should be done for targets at various bearings, some moving to the right and some moving to the left. In this check,some small error is to be expected because there is always some lag-and-lost motion in the follow-up servomechanisms. Regardless, the error observed when tracking to the left should be essentially equal to that observed when tracking to the right and should be in the opposite direction. If the errors do not change direction when the direction of tracking is changed or if they are considerably larger for one tracking direction than the other, a misalignment is indicated This can be corrected by adjusting the train synchros. Before any adjustment is changed, however, a careful analysis should be made to be certain that the error is not caused by some other factor. For example, a misalignment of the sight telescope could cause an error. This should be corrected by boresighting the telescope, not by adjusting the synchros. Adjusting the synchros, in this case, would result in firing errors. If, after careful analysis, an adjustment is made to the synchros, a check should be made to see whether or not a corresponding adjustment must be made to the dials or any other part of the system.

As you can see, every component in a weapons system is linked either directly or indirectly to the others, as are the operators and maintainers of the equipment. You must think and act in terms of the weapons system as a whole. What you do, and how your equipment operates, will affect the operation of the system as a unit.

Before undertaking any alignment tasks, you should become thoroughly familiar with the contents of SW225-AO-MMA-010/OP762, *Align Theory, Theory of Combat System Alignment Manual.* This publication will assist you in obtaining a general understanding of the total combat system alignment methods. It defines combat system alignment, why it is needed, and what it does and does not accomplish. The principles of alignment and the general reasoning behind the procedures involved in alignment are explained. Detailed instructions for the alignment of specific systems are not covered in this TRAMAN.

The SW225/OP 2456 series, *Total Combat System Alignment Manual,* contains specific alignment procedures for each class of ship. This publication is intended to be used as a guide when performing combat system alignment. It is to be used in conjunction with PMS testing and maintenance. PMS tests are designed to check the proper operation of all the subsystems, either as a single entity (total combat system) or as individual subsystems. Although most PMS tests are not developed solely for alignment purposes, review of the results of those tests that provide alignment verification over a period of time will indicate trends toward out-of-tolerance alignment conditions.

The importance of maintaining an alignment smooth log cannot be overemphasized. Upon completion of the alignment, data must be documented to provide information for future alignments and to inform responsible personnel of system and subsystem alignment status. A complete and accurate alignment data package is essential for effective combat system alignment.

Upon completion of the initial, or a subsequent, alignment by a shipyard or support activity, an alignment report is submitted to the ship's commanding officer. The data in this report becomes the base line information in the Combat Systems Smooth Log for future system alignment verification. The Combat Systems Smooth Log is a perpetual record of all alignment, calibration, and internal ballistic data. The importance of maintaining the smooth log cannot be overemphasized. A general outline of data that should be included in the smooth log is provided in table 11-1. Reproducible forms for use in the Combat Systems Smooth Log are located in the back of SW225-AO-MMA-010/OP762.

The Combat Systems Smooth Log, section J, contains weapon system configuration data from the *Ship Configuration and Logistics Support Information System* (SCLSIS) Manual for your ship. The central SCLSIS data base contains the configuration information related to each unit's installed and planned equipment hardware. It identifies the proper level of logistics support required to maintain each piece of equipment. Through the SCLSIS process, configuration data is passed to the Weapon Systems File (WSF) at SPCC, which is used to determine spare parts requirements for ships. The on-board availability of spare parts is critical to keeping your systems up and operational. Therefore, you should always make sure this section is 100 percent accurate. For more information on SCLSIS and SCLSIS reporting, see NAVSEA Technical Specification 9090-700A.

SUMMARY

The main role of a GM is to deliver the ordnance on target. Your weapon system may be fully operational, but if you cannot hit your target, it's useless. The importance of accurate battery alignment cannot be overemphasized. Although some alignment procedures are described in this chapter, it is more important that you know where to find alignment procedures and instructions that are written specifically for the systems you will be working with on a daily basis.

Table 11-1.—Smootb Log Data and General Outline

Data	S	G	M	U	N
Section A - Alignment					
a. Record of checks (changes if any), dates held, and methods used	X	X	X	X	X
b. Collimation data dates and results of radar antenna and X beam	X	X	X		
alignment	X				
c. All plots of roller path, cutout cams and zones (firing and radiation),		X	X	X	
and horizon checks	X				
d. Bench mark readings and plate locations, tram readings		X	X	X	
(including bearing of mount for elevation tram, when applicable)					
Section B - Calibration		X			
a. Double echo checks and resultant settings				X	
b. Sonar calibration and source levels					X
c. Divergence					
Section C - Range finder calibration		X			
a. Record of range finder calibration checks and adjustments		X			
b. A curve for range finder, and a smooth copy of each operator's B curve					
Section D - Erosion		X			
a. Star gauge data		X			
b. Records of erosion gauge readings		X			
c. Records of bore searches		X			
d. Equivalent service rounds					
Section E - Rounds fired					
Entries in tabular form for each gun and/or launcher showing rounds fired,		X	X	X	
projectile, powder charge, etc.					
Section F - Firing reports		X	X	X	
File of all firing reports kept in chronological order					
Section G - Competitive exercise reports		X	X	X	
File of all competitive exercise reports					
Section H - List of test equipment	X				
A list of test equipment grouped by type and listed by title, mark, mod, and		X	X	X	
serial number					
Section J - Ship Configuration and Logistics Support Information	X				
System (SCLSIS)		X	X	X	
Subsystems and equipment portion of current SCLSIS					

Legend

S = Search Radar Subsystem
G = Gun Weapon Subsystem
M = Missile Weapon Subsystem
U = Underwater Weapon Subsystem
N = Navigation System